Weld Australia

TGN-SW02

Weld Australia
Technical Guidance Note

Laser Safety

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Foreword

This Technical Guidance Note is a revision of the 2020 edition, and includes advice on the safe use of hand-held laser devices used for cutting, welding, surfacing and cleaning. This revision has taken cognisance of the requirements of the latest editions of the following Standards:

- AS/NZS 1336;
- AS/NZS 1337.5;
- AS/NZS ISO 19818.1;
- AS/NZS IEC 60825.1;
- AS/NZS IEC 60825.14;
- IEC 11553-1; and,
- IEC 11553-2.

Acknowledgement

Weld Australian would like to thank Cameron Jamieson (Industrial Laser Solutions) and Dr Cornelis van Niekerk (Weld Australia) for their assistance in the preparation of this edition of this Technical Guidance Note.

Future Revisions

This Technical Guidance Note will be revised from time to time and comments aimed at improving its value to industry will be welcome.

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National Library of Australia card number and ISBN 978-1-920761-93-6

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About Weld Australia

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Weld Australia represents the welding profession in Australia. Our members are made up of individual welding professionals and companies of all sizes. Weld Australia members are involved in almost every facet of Australian industry and make a significant contribution to the nation's economy.

Our primary goal is to ensure that the Australian welding industry remains both locally and globally competitive, both now and into the future.

A not-for-profit, membership-based organisation, Weld Australia is dedicated to providing our members with a competitive advantage through access to industry, research, education, certification, government, and the wider industrial community.

Weld Australia is the Australian representative member of the International Institute of Welding (IIW).

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Our vision is to facilitate the growth of a world class welding industry in Australia.

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Weld Australia generates revenue through its commercial activities which is then reinvested back into the welding community for the benefit of members.

Weld Australia brings individual and company members together to deliver:

- A forum for the exchange of ideas and the sharing of resources
- A voice to promote the interests of the welding community and shape the market for welding services
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1.0 Introduction

This Technical Guidance Note provides users of Laser equipment with guidance as to the safety requirements of lasers emitting a range of wavelength radiation at power levels up to and including those capable of being utilised for welding and cutting operations, including hand-held laser devices.

This Technical Guidance Note should be read in conjunction with the referenced Standards including the IEC and European Standards adopted within the referenced Standards so as to minimise the risk of exposing people to hazardous levels of laser radiation resulting from the use and operation of laser equipment.

2.0 Classification of Lasers

The basic approach to virtually all laser safety standards has been to classify lasers by their hazard potential, based upon their optical emission. According to AS/NZS IEC 60825.1 *Safety of laser products Part 1: Equipment classification and requirements*, the manufacturer of lasers and laser products is required to certify that the laser is designated as one of eight general classes, or risk categories, and label it accordingly. This allows the use of standardised safety measures to reduce or eliminate accidents depending on the class of the laser or laser system being used.

The following is a brief description of the categories of lasers (see also AS/NZS 1336):

- **Class 1**
  A Class 1 laser is considered safe based upon current medical knowledge. Under normal operating conditions Class 1 lasers or laser systems cannot produce a hazard and no safety measures are required. A Class 1 laser could also be a higher-class laser that is completely enclosed to prevent personnel exposure to the laser beam. Two Class 1 sub categories exist:
  - Class 1C: Class 1C applies where the beam directly impacts the intended target and engineering controls are applied to the beam to prevent leakage at levels higher than that permitted for Class 1.
  - Class 1M: Class 1M lasers exceed the emission levels of Class 1 lasers but because of the beam divergence do not present a hazard to the un-aided eye. If magnifying instruments such as binoculars, telescopes, magnifiers or microscopes etc are used to view the beam, eye damage can occur.

- **Class 2**
  A Class 2 laser or laser system is defined as operating in the visible region (400-700nm). These lasers are not inherently safe but protection against eye damage will normally be afforded by aversion responses including the blink reflex. Momentary viewing (exposure of 0.25 second or less) is not considered hazardous. Intentional extended viewing, however, is considered hazardous. There is one sub category of Class 2:
  - Class 2M: Class 2M lasers operate in the visible region (400-700nm) but at higher power levels than Class 2 lasers. Because of the spread of radiation, they afford limited protection against eye damage due to the blink reflex and its response to bright sunlight. If the beam is columnated by optics in the beam, or the beam is viewed through optical instruments including binoculars, telescopes, magnifiers or microscopes etc, then the blink reflex provides little protection and the beam is considered hazardous.

- **Class 3**
  Class 3 lasers are medium-power lasers that pose a modest potential for injury. Class 3 laser users may be required to follow specific safety precautions and may require the wearing of safety equipment such as laser protective eye wear. Skin hazards normally do not exist for incidental exposures. Two Class 3 sub-categories exist:
  - Class 3R (Restricted): Class 3R (Restricted) lasers or laser systems can emit either invisible or visible radiation and operate at up to 5 times the power of Class 1 lasers (invisible radiation) or Class 2 lasers (visible radiation) but have higher levels (25 to $50W.m^{-2}$) of irradiance. Whilst this class represents a low level eye hazard, direct eye exposure should be avoided. Where used in conditions of lower illuminance (generally less than 10 lux), the appropriate safety controls are those specified for Class 3B laser products.
  - Class 3B: Class 3B lasers can emit either invisible or visible radiation and direct viewing is hazardous to the eye. Class 3B lasers are capable of causing eye injury either because their output is invisible and therefore aversion responses are not activated, or because the beam power is such that damage is done in a time shorter than the blink reflex (0.25s). Higher power lasers in this class may also cause skin burns. However, with laser wavelengths other than those in the ultraviolet region, the pain produced by rapid heating of the skin will usually evoke an aversion response sufficient to avoid such burns.

- **Class 4**
  Class 4 lasers are high-power lasers that pose a serious potential for injury of the eye and skin and require that users follow specific safety precautions and wear laser protective eyewear. They may operate in any part of the spectrum, as with the 3B. Class 4 laser systems can produce a hazard not only from direct or specular reflections, but also from a diffuse reflection. A fire risk may also be associated with the use of such high powered systems and their use requires extreme caution.

Of these classifications, only Class 4 lasers are incorporated into systems used for materials processing such as cutting, heat treatment, surfacing and welding. A Class 4 laser may be part of a system designed in such a manner as to be considered a Class 1 laser system. Such a system cannot under normal operating conditions, produce a hazard. This can be achieved using engineering controls such as enclosures, interlocks, and other mechanisms.

It is the duty of the manufacturer of the laser to classify the product and consequently to place warning labels on the product and to realise safety features such as key-locks and interlock connectors. However, if the user manipulates the laser product so that the class is changed, the user becomes responsible for the re classification of the laser.

3.0 Safety with Industrial Lasers (Beam and Non-Beam Hazards)

Potential hazards related to the use of lasers can generally be divided into primary and secondary hazards. The laser beam itself represents the primary potential hazard, as it can affect humans or objects – in the form of raw beam, focussed beam, directly reflected beam, or scattered radiation.

Secondary potential hazards are further subdivided into direct and indirect hazards:

- Direct potential hazards are caused by technical components of the laser installation (high voltage, excitation radiation, laser gases, optics),
- Indirect potential hazards are generated by the interaction of the laser beam with materials or the atmosphere.

> ***NOTE**: Indirect potential hazards include the UV-radiation caused by plasma formation, hazardous substances generated during material processing, and also potential ignition of explosive materials and the danger of fire.*

The division of potential hazards is shown in Figure 1.

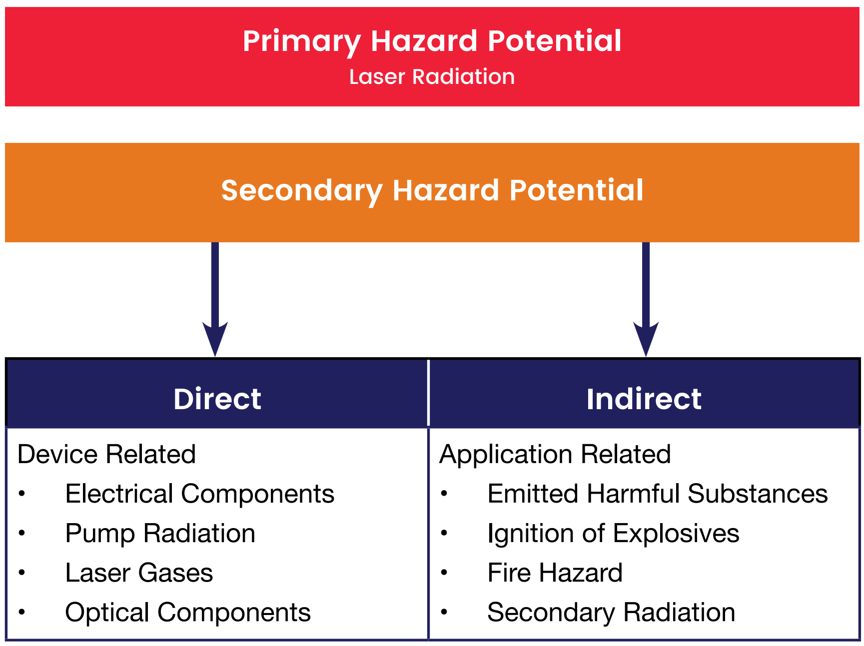

Figure 1: Hazards caused by laser material processing.

3.1 Laser Radiation

There are two potential dangers to personnel associated with laser radiation: eye and skin damage.

The factors that can contribute to tissue injury and influence the degree of damage from laser beam exposures include:

(a) Wavelength of laser radiation.
(b) Tissue spectral absorption, reflection and transmission.
(c) Strength of irradiance of incident laser beam.
(d) Size of irradiated area.
(e) Exposure duration.
(f) Pupil size.
(g) Location of retinal injury.
(h) Laser pulse characteristics.

Depending on wavelength, damage to either the cornea, the retina, or both, of the eye is possible. Exposure to radiation from a CO_2 laser (1060 nm) typically results in corneal damage. The radiation from an Nd:YAG laser (and similarly for Ytterbium hand held laser welders), at 1064 nm, is much closer to the visible spectrum (400 to 700 nm) and can be transmitted by the cornea and lens. The lens will focus the laser light on the retina, causing severe and permanent damage to the retina and other intraocular material including instant (and permanent) blindness. This focusing, by the lens of the eye, can cause even low-power diffuse laser light to be focussed to a sufficient power density to cause retinal damage. Low-power helium-neon (He-Ne) lasers (633 nm), often used for alignment purposes, may also present a hazard.

Skin damage is restricted primarily to burns. It should be noted, however, for high-powered lasers these burns can be deep and cause severe and permanent damage.

The most effective prevention of injury is to ensure that the laser beam is encapsulated so that no human exposure can occur. For the case of an exposure to the beam, the level of exposure will determine if injury occurs. The level of exposure or irradiance which can be thought of as the border between safe and potentially harmful is called “Maximum Permissible Exposure”, MPE.

The area around a laser installation where the MPEs for the eye can be exceeded is called the “Nominal Ocular Hazard Area”, NOHA. The corresponding distance from the laser exit aperture is called the “Nominal Ocular Hazard Distance”, NOHD. The NOHD depends on the laser power, geometrical laser beam parameters such as the divergence, and the MPE. MPE values for the eye and the skin as a function of wavelength and exposure duration are listed in AS/NZS IEC 60825.14. The standard also contains a number of sample NOHD calculations for a range of geometries and exposure situations.

To take account of the use of various magnifiers, AS/NZS IEC 60825.14 also refers to a parameter called the “Extended Nominal Ocular Hazard Area” or ENOHA. The extended nominal ocular hazard area is therefore the distance beyond which it is safe to use various magnifiers.

As MPE, NOHD and ENOHD evaluations are quite complicated and involved, the laser classification scheme outlined earlier is used for the hazard evaluation process. For instance, for Class 1 lasers, the exposure will always be below the MPE. Class 3B lasers emit radiation which is significantly above the MPE for eye, and for Class 4 also above the MPE for the skin, however, it depends on the beam geometry, set-up and application, if this hazard exists only close to the exit aperture or if it extends over several kilometres.

3.1.1 Eye Protection

Information on eye protectors suitable for use with particular lasers and operations together with their required marking is given in AS/NZS ISO 19818.1 *Eye and face protection — Protection against laser radiation Part 1: Requirements and test methods* and AS/NZS 1337.5 *Face and eye protection Part 5: Eye protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)*.

The following should be considered when specifying suitable protective eyewear:

(a) Wavelength(s) of operation.
(b) Radiant exposure or irradiance.
(c) Maximum permissible exposure (MPE).

(d) Optical density of eyewear at laser output wavelength.
(e) Visible light transmission.
(f) Radiant exposure or irradiance at which damage to eyewear occurs.
(g) Need for prescription glasses.
(h) Comfort and ventilation.
(i) Degradation or modification of absorbing media, even if temporary or transient.
(j) Strength of materials (resistance to shock).
(k) Peripheral vision requirements.
(l) Any relevant legislation.

A method of selecting the laser or laser adjustment eye protector most suited to the hazards associated with the use of a particular laser is given in AS/NZS 1336 *Eye and face protection—Guidelines*.

Special attention has to be given to the resistance and stability against laser radiation when choosing eyewear for Class 4 laser products, including hand-held laser welders. Laser eye protectors compliant with AS/NZS ISO 19818.1 are marked with their protection wavelength, optical density and laser pulse type and duration. Some laser eye protecters may also offer a level of impact resistance. These performance characteristics are determined by the manufacturer.

In addition, laser eye protectors compliant with EN 207 have both a defined shelf-life and working life from the date marked on the eyewear. The self-life and working life are determined by the manufacturer.

NOTE: *Face shields compliant with EN207 are also commercially available.*

Laser eye protectors and laser adjustment eye protectors which have been damaged or have undergone a colour change, or have exceeded their shelf-life or working life must not be used. Eye protectors are only intended to protect against accidental exposure as the ratings are based on a maximum exposure of 10s (for a continuous wave laser) or 100 pulses (for a pulsed laser). Eye protectors are not intended to be used for looking directly into the beam.

A precaution must be added here – standard safety glasses alone do not provide protection. Any laser eyewear, plain or prescription, **must** be labelled in accordance with AS /NZS ISO 19818.1 with information adequate to ensure the proper choice of eyewear with particular lasers. In some laser systems, ultraviolet light may be leaked into the workplace. Thus, the eyewear should provide primary beam protection, secondary radiation protection and also ultraviolet protection. Note that safety glasses must be labelled in accordance with AS/NZS 1337.1 or AS/NZS 1338.1.

3.1.2 Skin Protection

Where personnel may be exposed to levels of radiation that exceed the MPE for the skin, suitable clothing should be worn. Class 4 laser products present a potential fire hazard and protective clothing worn should be made from a suitable flame and heat-resisting material.

Special attention must be given to resistance and long-term stability against laser radiation when choosing protective clothing for use with Class 4 laser products.

3.2 Electrical Hazards

The voltages used in lasers are sufficient to cause fatal injuries to personnel and account for most laser-related fatalities. All electrical equipment associated with laser beam materials processing should be installed in conformance to AS/NZS 3000 *Electrical installations*.

All doors and access panels should be properly secured, either electrically or mechanically, to prevent access by unauthorised personnel to electrical components, especially those operating at the laser excitation potential. All personnel working on or around high-voltage components should be trained in the proper safety techniques for electrical systems, as well as in the technique of removing a victim from an electrical circuit and administering cardiopulmonary resuscitation (CPR). Personnel should be aware of and adhere to any additional electrical safety requirements of the laser system installed in their facility. Usually, the best source of safety information is provided in the instruction manual from the manufacturer of the laser system. Always read, understand and follow the manufacturer's recommended safety procedures.

3.3 Fumes and Gases

Welding, cutting and drilling, and surface modification with lasers may result in the generation of fumes, dust, and gases that can be hazardous to personnel.

These airborne contaminants may include:

(a) Vapourised target material and reaction products in the form of metal particles and oxides.
(b) Metallic dusts arising from the use of fine metal powders.
(c) Gases from the flowing gas laser systems or from the by-products of laser reactions, such as ozone, nitrous oxide, carbon monoxide and carbon dioxide.
(d) Gases or vapours from cryogenic coolants.
(e) Gases used to assist laser-target interactions, such as oxygen.

The hazards associated with welding and cutting of metals have been documented in a variety of publications including Weld Australia's *Fume Minimisation Guidelines*. It should be noted that some organic materials such as plastics can generate fumes that are hazardous e.g. poly-aromatic hydrocarbons (PAH). Care should be taken to avoid the excessive build-up of laser discharge gases, shielding gases, and assist gases, especially in enclosed spaces where oxygen can be displaced.

Fine metallic powders often used during additive manufacturing, laser surfacing and cladding operations, are a respiratory and fire/explosion hazard, and proper care should be given to the safe use and handling of these metallic powders.

> ***NOTE**: An ISO standard for the safe use of use of metallic powders in additive manufacturing has been published (see ISO/ASTM CD 52931). ISO 11553-1 provides guidance on potential hazards associated with the use of lasers including hazardous substances produced during laser cutting, welding and cleaning.*

All necessary environmental engineering measures for fume and gas control (fume capture and external venting, use of respirator masks, filtering, etc) including good general ventilation should be taken to prevent the accidental inhalation of harmful concentrations of dusts, fumes and gases by personnel working on or around laser materials processing equipment. Exhaust of these fumes may violate local or federal standards, and implications should be considered before using equipment. The possible toxicity of the workpiece and consumables (wire, powder, etc) should be determined before laser beam materials processing begins. Adequate protection to personnel should be provided – refer to Weld Australia's Technical Note 7 *Health and Safety in Welding* and the *Fume Minimisation Guidelines*. Also, for all materials, the Safety Data Sheet (SDS), available from the material supplier, should be consulted to determine what hazards exist.

3.4 Fire Hazard

Since the laser system produces a very small spot size with high energy, the hazard of fire is present if the beam hits flammable material. Keep flammables away from the welding or cutting area. Be sure to cover and protect anything flammable in the area since reflected radiation could start fires in unexpected areas.

The potential for explosions at the capacitor bank or optical pump systems exists during the operation of some high-power laser systems. Metallic and non-metallic dusts such as airborne particles coming from the target area in the laser cutting, drilling and welding operations may be capable of causing fire or explosion. Explosive reactions of chemical laser reagents or other chemicals or gases are also possible.

3.5 Secondary Radiation Hazards

Viewing of the visible radiation emitted during laser materials processing can also be harmful to eyesight. During welding, a bright plume, similar in appearance to a welding arc, is generated from the interaction between the laser beam and material being processed. The size and intensity of this plume is a function of the material being processed, the power level, and the shielding gas used. Consequently, no exact guidelines can be given. However, the radiation emitted is broadband, from the ultraviolet, which can cause sunburn and arc eye, through the visible to the infrared, which can contribute to the formation of cataracts.

As the plume is generally too bright for direct viewing, adequate filtering, such as welding shades, should be employed for eye protection. As a general guideline, the filter used should be of sufficient optical density to ensure the viewer's comfort at the highest level of light intensity encountered and there should be no evidence of eye irritation after exposure. The optical viewing system should provide filtering in conformance to AS/NZS 1337.1 and

AS/NZS 1338.1 and should include provisions for filtering the visible and ultraviolet radiation from the plume as well as the laser radiation. All persons involved with laser beam materials processing should be instructed in the use of proper optical filtering and should be required to use such protection.

3.6 Optical Fibre System Associated Hazards

There are many Nd:YAG lasers on the market now where fibre beam delivery is the only method of energy delivery. The optical fibre alone should not be relied on as a safe enclosure. Hazardous situations associated with the optical fibre itself include:

- Leakage due to inappropriate acceptance angle.
- Leakage due to the fibre being subject to too tight a bending radius.
- Fibre breakage due to excessive bending or twisting. If the fibre is carrying laser power at the time the break occurs then, because of the relatively small fibre diameter, the laser beam will emerge from what is effectively a high intensity point source as a divergent beam.
- Leakage and excess heat generation due to the ingress of dirt or other contamination onto the fibre input or output faces.

Note that Ytterbium and other hand-held laser welders also use an optical fibre beam delivery system.

4.0 Control Measures for Laser Installations

4.1 General

Laser systems used for materials processing can cause injury from both the direct beam or its specular reflections and from diffuse reflections. They also present associated hazards as outlined above. The following control measures should be employed to minimise these risks:

(a) The laser should only be operated in a controlled area. Class 4 lasers should be operated by remote control, whenever practicable, thus eliminating the need for personnel to be physically present in the laser environment.

(b) The entrances to areas should be posted with a standard laser warning sign as specified in AS/NZS IEC 60825.1. The installation of a "Laser on" warning light or signal is also recommended.

(c) Beam paths should:

(i) Be enclosed whenever practicable, and access to the laser environment during laser operation should be limited to persons wearing proper laser protective eyewear and protective clothing.

(ii) Avoid the work area where possible, and long sections of tubes should be mounted so that thermal expansion, vibration, and other sources of movements in them do not significantly affect the alignment of beam forming components.

(iii) Consider the risk of possible entanglement of fibre optic cables running from the laser ignition source to the robotic arm, and, hoses carrying:

- cooling water for the robot head;
- shielding gasses; and,
- gases carrying metallic powders.

***NOTE**: Careful consideration needs to be given to the room layout robotic setup, and powder feeders to prevent such entanglements as this will lead to hazards and accidents and the compromise of the quality of the fibre optics.*

(d) Good room illumination is important in areas where laser eye protection is worn. Light-coloured diffuse wall surfaces help to achieve this condition.

(e) Fire, thermally induced aberrations in optical components and the melting or vaporisation of solid targets designed to contain the laser beam, are all potential hazards induced by the radiation of Class 4 lasers. A suitable beam stop should be provided. Materials which may be degraded by the beam must be avoided.

(f) Special precautions may be required to prevent unwanted reflections, especially for infrared laser radiation, and the beam and target area should be surrounded by a material opaque to the laser wavelength. Even dull metal surfaces may become highly specular at the CO_2 wavelength of 10.6µm. Local screening should be used wherever practicable to reduce the extent of reflected radiation.

(g) The alignment of optical components in the path of a Class 4 laser beam should be initially and periodically checked.

(h) The remote interlock connector should be connected to an emergency master disconnect interlock or to room, door or fixture interlocks. The person in charge may be permitted momentary override of the remote interlock connector to allow access to other authorised persons if it is clearly evident that there is no optical radiation hazard at the time and point of entry.

Laser systems not in use should be protected against unauthorised use by removal of the key from the key control.

Additional guidance on laser safety including the identification laser hazards and the assessment of is available in AS/NZS IEC 60825.1 and ISO 11553-1.

> **NOTE**: *High-power lasers used for welding, surfacing, cleaning and cutting of materials operate in both the visible and infrared (invisible) spectral region. With a NOHD of over 3km for continuous wave lasers and 300m for pulsed lasers, they pose a serious risk of injury of the eye including permanent and instant blindness, and burns/penetration of the skin. Specific safety precautions provided by the laser system manufacturer must be followed. As indicated in (e) above, a fire risk may also be present.*

4.2 Hand-held Laser Welders

Hand-held laser welders are typically Class 4 devices are capable of inflicting serious and permanent injuries including permanent eye damage and blindness. The general safety precautions listed in 4.1 also apply to hand-held laser systems used for welding and cleaning. Recommended precautions include:

a) Appointing a trained laser safety officer to manage the safe the use of the laser device (see 6.0).
b) Hand-held laser welders should only be operated in a laser-controlled area with the entrance(s) to the areas posted with a standard laser warning sign (see AS/NZS IEC 60825.1). This allows suitable precautions to be taken to prevent direct and indirect (including diffuse reflections) laser radiation impacting the laser operator and any person including those outside of the laser-controlled area.
c) Limiting access to the laser-controlled area to persons trained in the safe use of the laser, and, wearing proper laser protective eyewear (see AS/NZS ISO 19818.1 and AS/NZS 1337.5).
d) Suitable protective clothing and gloves being worn (by the operator and personnel potentially exposed to the beam) to protect the skin from direct and/or indirect beam contact.
e) Application of engineering controls including:
    (i) Hand-held laser welders must not be operable when not in contact with the workpiece.
    NOTE: Hand-held laser welders are typically fitted with a work piece lead which is attached directly to the workpiece. Some machines also incorporate additional protective measures to prevent activation should contact with the workpiece be compromised e.g. plasma detection.
    (ii) Locking out laser systems not in use to protect against unauthorised use. Options include the removal of the key from a key-controlled activation switch, use of lockout isolation systems etc.
    (iii) Fitment of an emergency stop (E-stop) switch to deactivate the laser within close proximity to the operator (see 4.1(h) and ISO 11553-2);
    (iv) Fitment/use of a remote interlock switch that deactivates the laser when a person attempts to enter the laser controlled area e.g. a door switch.
    (v) Good general ventilation and fume capture (see 3.3) in enclosed areas to prevent fume build-up and exposure to hazardous fumes.

Additional guidance on the safe use of hand-held laser devices can be found in ISO 11553-2 and AS/NZS IEC 60825.14.

Where required, locations with restricted laser access to allow untrained personnel such as observers can be provided through the use of transparent laser safe viewing windows in the laser-controlled access location.

4.3 Laser Cleaners

Similar to hand-held laser welders, laser cleaning systems are typically Class 4 devices capable of inflicting serious and permanent injuries including permanent eye damage and blindness. The general safety precautions for hand-held laser welders should be followed noting that laser cleaning devices are intentionally not required to operate in direct contact with the workpiece.

In addition to the above, the following recommended precautions should be applied:

a) Laser cleaners should:

(i) Preferably be operated in a laser-safe enclosure with enclosed walls and roof to prevent direct or indirect radiation exposure; or,

(ii) Where the workpiece cannot be taken to the enclosure, a suitable enclosure should be erected around the workpiece using laser-safe screens around and above the workpiece to prevent the escape of laser radiation beyond the enclosure. Any windows within the workspace should be covered unless they are verified as opaque to laser radiation.

b) Barricades should be erected to clearly delineate the laser controlled area with appropriate Class 4 laser warning signage clearly displayed, with access restricted to persons trained in the safe use of the laser, wearing proper laser protective eyewear, and wearing appropriate protective clothing including leather gloves (see 4.2). Ideally, an electrical interlock should be fitted to the laser to automatically deactivate in the event of unauthorised entry to the laser-controlled area.

c) Depending on the material being cleaned, the fume arising from the laser cleaning process is likely to be both acrid and toxic i.e. hazardous. WHS regulations require that the hazards be clearly identified and either eliminated or minimised as far as reasonably practicable. Engineering controls including capturing the fume at source will need to be applied in combination with good general ventilation. Due to the acrid and toxic nature of the fume, the operator will most likely also need to be fitted with either a powered air purifying respirator (PAPR) or air-fed respirator incorporated into their laser-safe headgear and facepiece assembly. Laser-safe safety glasses should also be worn under the face mask.

5.0 Medical Surveillance

Laser workers whose work involves a significant risk of exposure to laser radiation in excess of the Maximum Permissible Exposure (MPE) should have eye examinations and, where appropriate, skin examinations carried out at commencement and termination of the position.

For anyone at increased risk of laser damage, more frequent eye examinations may be prudent.

6.0 Laser Safety Officer

Work health and safety (WHS) regulations throughout Australia require that all hazards to health and safety are identified and eliminated, at least as far as reasonably practicable. The Class 3B and Class 4 lasers (including hand-held laser welding and cleaning equipment) are particularly hazardous. See also ISO 11553 1, ISO 11553 2 and AS/NZS IEC 60825-14.

For each organisation using potentially harmful laser systems, the person controlling the business or undertaking (i.e. PCBU or management) should assign an individual to serve as a “Laser Safety Officer” or LSO to be responsible for their safe use. The LSO should receive LSO specific laser safety training and have access to laser safety guidance documents, equipment and support staff commensurate with the extent of their responsibilities.

> **NOTE**: *The “Laser Safety Officer” is defined in AS/NZS IEC 60825.14 as “one who is knowledgeable in the evaluation and control of laser hazards and has responsibility for oversight of the control of laser hazards”.*

The LSO requires this authority from management to ensure users maintain safe practices with their equipment. Management may employ an LSO to oversee the responsibility while relying on technical input from an outside expert.

The LSO undertakes a risk assessment before a laser or laser system is first used, or after it has been modified. The LSO determines potentially hazardous areas, degree of hazard, and the necessary risk reduction measures through administrative and engineering controls.

Such controls include, the necessary safety instructions, and determination of appropriate personnel protective equipment such as optical density (OD) for laser protective eyewear. The LSO also maintains an inventory of lasers with detailed information such as: manufacturer, model number, quantity, physical location, user organisation, laser active medium, laser radiant power or energy, laser radiant wavelength(s), laser application, and laser hazard category. Other useful information (e.g. history and last maintenance date) may be required by an individual LSO.

Additional information on the role of the LSO can be found in AS/NZS IEC 60825.14. Importantly, the LSO should ensure that verification checks of the safety requirements and risk reduction measures in place (see also ISO 11553-1) are undertaken by a competent person.

7.0 References

References referred to in the text:

1. AS/NZS 1336 Recommended practices for occupational eye protection
2. AS/NZS 1337.1 Personal eye protection: Eye and face protectors for occupational applications
3. AS/NZS 1337.5 (EN 208) Face and eye protection Part 5: Eye protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)
4. AS/NZS 1338.1 Filters for eye protectors Part 1: Filters for protection against radiation generated in welding and allied operations
5. AS/NZS ISO 19818.1 Eye and face protection – Protection against laser radiation, Part 1: Requirements and test methods
6. AS/NZS IEC 60825.1 Safety of laser products Part 1: Equipment classification and requirements
7. AS/NZS IEC 60825.14 Safety of laser products Part 14: A user guide
8. AS/NZS 3000 Electrical installations (known as the Australian / New Zealand Wiring Rules)
9. IEC 11553-1 Safety of machinery – Laser processing machines – Part 1: Laser safety requirements
10. IEC 11553-1 Safety of machinery – Laser processing machines – Part 2: Safety requirements for hand-held laser processing devices
11. Weld Australia Technical Note 7 Health and Safety in Welding
12. Weld Australia Technical Guidance Note TGN SW01 Fume Minimisation Guidelines

For further reading, reference may be made to the following:

- AWS C7.2M Recommended Practices for Laser Beam Welding, Cutting, and Allied Processes
- ISO/ASTM 52931 Additive manufacturing – Environmental health and safety – General principles for use of metallic materials
- Laser Institute of America (LIA), Laser Materials Handbook
- AWS Fact Sheet No.19. Laser Beam Welding and Cutting Safety
- AWS Fact Sheet No.46. Handheld Laser Welding, Cutting, and Cleaning Safety
- Handbook on Industrial Laser Safety. K.Schröder (ed.), ARGELAS

Weld Australia Technical Notes

TN 1 - The Weldability of Steels

Gives guidance on the preheat and heat input conditions (run size, current, voltage) required for acceptable welds and to avoid cold cracking in a wide variety of steels. The Note is applicable to a wide range of welding processes.

TN 2 - Successful Welding of Aluminium

This note covers the major welding processes as they are used for the welding and repair of aluminium and its alloys. Information is given on the processes, equipment, consumables and techniques. It also provides information on the range of alloys available and briefly covers safety, quality assurance, inspection and testing, costing and alternative joining processes.

TN 3 - Care and Conditioning of Arc Welding Consumables

Gives the basis and details for the correct care, storage and conditioning of welding consumables to control hydrogen and to ensure high quality welding.

TN 4 - The Industry Guide to Hardfacing for the Control of Wear

Describes wear mechanisms and gives guidance on the selection of hardfacing consumables and processes for a wide range of applications. Includes Australian Hardfacing Suppliers Compendium 1998.

TN 5 - Flame Cutting of Steels

Gives a wealth of practical guidance on flame cutting including detailed procedures for efficient cutting, selection of equipment and gases, practices for identifying and curing defective cutting, methods of maximising economy and other important guidance on the use of steels with flame cut surfaces.

TN 6 - Control of Lamellar Tearing

Describes the features and mechanisms of this important mode of failure and the means of controlling tearing through suitable design, material selection, fabrication and inspection. Acceptance standards, repair methods, specification requirements and methods of investigation are proposed. Four appendices give details on the mechanism, material factors, tests for susceptibility and the important question of restraint.

TN 7 - Health and Safety in Welding

Provides information on all aspects of health and safety in welding and cutting. Designed to provide this information in such a way that it is readily useable for instruction in the shop and to provide guidance to management. Recommendations are given for safe procedures to be adopted in a wide variety of situations in welding fabrication.

TN 8 - Economic Design of Weldments

Principles and guidance are given on methods and procedures for optimising design of weldments and welded joints and connections to maximise economy in welding fabrication. Factors influencing the overall cost of weldments which need to be considered at the design stage are discussed.

TN 9 - Welding Rate in Arc Welding Processes: Part 1 MMAW

Gives practical guidance and information on the selection of welding conditions to improve productivity during manual metal arc welding (MMAW). Graphs are provided showing rates as a function of weld size. The graphs enable a direct comparison of different types of welding electrodes when used for butt and fillet welds in various welding positions.

TN 10 - Fracture Mechanics

Provides theory and gives practical guidance for the design and fabrication of structures, planning of maintenance and assessment of the likelihood of brittle or ductile initiation from flaws in ferrous and non-ferrous alloys. Engineering critical assessment case histories are discussed.

TN 11 - Commentary on the Structural Steel Welding Standard AS/NZS 1554

The Note complements AS/NZS 1554 parts 1 to 7, by presenting background information which could not be included in the Standard. It discusses the requirements of the Standard with particular emphasis on new or revised clauses. In explaining the application of the Standard to welding in steel construction, the commentary emphasises the need to rely on the provisions of the Standard to achieve satisfactory weld quality.

TN 12 - Minimising Corrosion in Welded Steel Structures

Designed to provide practical guidance and information on corrosion problems associated with the welding of steel structures, together with possible solutions for minimising corrosion.

TN 13 - Stainless Steels for Corrosive Environments (A Joint publication with ACA)

Provides guidance on the selection of stainless steels for different environments. Austenitic, ferritic and martensitic stainless steels are described together with the various types of corrosive attack. Aspects of welding procedure, design, cleaning and maintenance to minimise corrosion are covered.

TN 15 - Welding and Fabrication of Quenched and Tempered Steel

Provides information on quenched and tempered steels generally available in Australia and gives guidance on welding processes, consumables and procedures and on the properties and performance of welded joints. Information is also provided on other fabrication operations such as flame cutting, plasma cutting, shearing and forming.

TN 16 - Welding Stainless Steel

This Technical Note complements Technical Note Number 13 by detailing valuable information on the welding of most types of stainless steels commonly used in industry.

TN 18 - Welding of Castings

Provides basic information on welding procedures for the welding processes used to weld and repair ferrous and non-ferrous castings. It also provides information on the range of alloys available and briefly covers non-destructive inspection, on-site heating methods and safety.

TN 19 - Cost Effective Quality Management for Welding

Provides guidelines on the application of the AS/NZS ISO 9000 series of Quality Standards within the welding and fabrication industries. Guidance on the writing, development and control of Welding Procedures is also given.

TN 20 - Repair of Steel Pipelines

Provides an outline of methods of assessment and repair to a pipeline whilst allowing continuity of supply.

TN 21 - Submerged Arc Welding

Provides an introduction to submerged arc welding equipment, process variables, consumables, procedures and techniques, characteristic weld defects, applications and limitations. Describes exercises to explore the range of procedures and techniques with the use of solid wire (single and multiple arcs) and provides welding practice sheets, which may be used as instruction sheets to supplement demonstrations and class work, or as self-instruction units.

TN 22 - Welding Electrical Safety

Provides information and guidance on welding electrical safety issues: welding equipment, the body and the workplace.

TN 23 - Environmental Improvement Guidelines

Provides information and guidance on how to reduce consumption in the Welding and Fabrication industry, while reducing the impact on the environment at the same time.

TN 25 – Welding Specification for the Water Industry

Published with the Water Services Association of Australia. Applies to all metal fabrication and repair work involving welding, carried out by a Water Agency (WA) and its Contractors/Subcontractors. Prescribes weld preparation, qualification of welding procedures and personnel, workmanship and inspection requirements for welds related to the arc welding by manual metal arc and other processes approved by the WA responsible Welding Coordinator.

Notes

Weld Australia

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